Volume 20 May, 1934 *Number 5*

Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

THIS ISSUE

Lubrication Practice in the Coal Industry

PUBLISHED BY
THE TEXAS COMPANY
TEXACO PETROLEUM PRODUCTS

TEXACO LUBRICATION RECOMMENDATIONS

for 

COAL MINING MACHINERY

BELOW GROUND

DRILLS, HAMMERS, STOPPERS, PUNCHERS AND PICKING MACHINES

Rotating and Reciprocating Elements	TEXACO ALCAID C, ALGOL C, OR TEXACO URSA OIL C
(Under Water Conditions)	TEXACO STAR LUBRICANT B OR C, OR TEXACO DRACO CYLINDER OIL
Chuck Fittings and Reduction Gears	TEXACO STAR GREASE NO. 00, NO. 1, OR TEXACO CUP GREASE NO. 1

MINE COMPRESSORS

Cylinders and Adjacent Mechanisms	TEXACO CETUS OR ALCAID OIL

CUTTING MACHINERY

Bearings *(Oil Lubricated)*	TEXACO NABOB, ALEPH, OR ALTAIR OIL
(Grease Lubricated—Waste Packed)	TEXACO STAR LUBRICANT B OR C
(Other Types)	TEXACO CUP GREASES TEXACO WOOL YARN GREASE
Gearings and Driving Chains	TEXACO THUBAN COMPOUNDS
Cutter Chains	TEXACO BLACK OILS
Wheel Bearings	(SEE MINE CARS)

COAL LOADERS

Gears and Chains *(Bath Lubricated)*	TEXACO PELICAN OIL, OR TEXACO THUBAN COMPOUNDS
(Where Grease is Advisable)	TEXACO STAR GREASES
Exposed Gears	TEXACO CRATER COMPOUNDS
Hydraulic Systems *(According to Type)*	TEXACO OILS*
Bearings *(Grease Lubricated)*	TEXACO CUP GREASES
(Oil Lubricated)	TEXACO NABOB OR ANSER OIL

MINE CAR AND OTHER WHEEL BEARINGS

Waste or Wool Yarn Packed Bearings	TEXACO WOOL YARN GREASE TEXACO STAR LUBRICANT A OR B, OR TEXACO BEARING OILS
Cavity Type Wheels *(Oil Lubricated)*	TEXACO BEARING OILS
(Grease Lubricated)	TEXACO MINE CAR GREASES
Roller Bearings *(Solid)*	TEXACO MARFAK GREASES OR TEXACO STAR GREASES
(Flexible)	TEXACO STAR LUBRICANT B

MINE LOCOMOTIVES

Electric Motor Bearings	TEXACO STAR GREASES TEXACO MARFAK GREASES
Air Cylinders	TEXACO ALCAID OIL
Gears	
(Exposed)	TEXACO CRATER COMPOUNDS
(Enclosed—Bath Lubricated)	TEXACO THUBAN COMPOUNDS

* Because of varied conditions of operation and design, consult Texaco Engineering Service.

(Continued on Inside Back Cover)

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Lubrication Practice in the Coal Industry

COAL mining is a matter of mass production. To be accomplished at minimum cost per ton it must be carried on with a variety of heavy duty materials handling machinery, capable of functioning efficiently under the most severe operating conditions. There was a time when the relation of lubrication to economical operation was given but little consideration, with the thought that at best it could but function imperfectly in the presence of excessive quantities of water, coal and rock dust.

The trend in design of modern coal mining machinery, however, has completely altered this picture, for the designing engineer has come to thoroughly realize the importance of lubrication as a factor in protecting the moving or contact parts of his machines, and the practicability of including systems or means of lubrication which can be adequately protected against entry of non-lubricating, abrasive or corrosive materials.

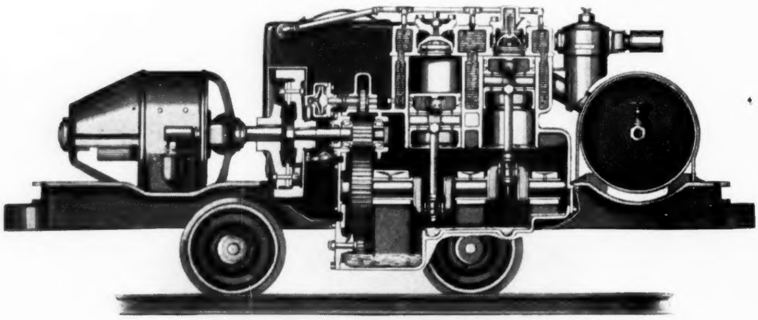
The necessity for protection of mining machinery in the interest of reducing repair expense and the cost per ton of coal produced, has been more recently emphasized, by the activity of competitive markets in liquid and gas fuels for industrial power and household heating purposes.

The result has been a development in methods of lubrication and an attitude toward selection of lubricants which are a decided credit to machinery builders and mine operators. The old order of events has passed. Today all concerned appreciate the value of lubrication as the outstanding factor in reducing power consumption and the cost of machinery maintenance. It is obvious that power consumption may sometimes be abnormal, even where lubrication is entirely effective, if lubricants of too heavy body are used. This will be particularly true where gearing is concerned, or in automatic lubricating systems in cold weather. For this reason the lubrication engineer should be frequently consulted by both machine designers and mine operators, for his knowledge of the physical characteristics and lubricating ability of his various products is the connecting link in the attainment of continued low cost production.

The machinery essential to the mining, handling and finishing of coal will, of course, depend upon the type of mine, the physical nature of the coal and the market for which it is to be prepared. Anthracite coal, for example, is generally broken out from the seams by blasting, after suitable drilling with air or electric drills or picks. Bituminous or soft coal, on the other hand, is mined by picking, punching, or cutting machines.

COMPRESSOR LUBRICATION

The wide extension of the use of compressed air to coal mine operations, and the adaptability of smaller types of portable compressors requires careful consideration of compressor lubrication. Protection of air tool lubrication can be improved by locating the source of air supply as close to the tools as practicable. In this way possibility of rust accumulations within long lengths of pipe, and subsequent interruption of the functioning of tool mechanisms can be reduced. This has been accomplished by design of a highly mobile type of motor driven mine compressor of low head construction which can be readily moved through galleries or from one level to another, with minimum change in piping connections, or by locating compressor rooms below ground.



Courtesy of Ingersoll-Rand Company.

Fig. 1—Section through an Ingersoll-Rand low head mine compressor. Note gear, bearing and cylinder construction; also means for complete lubrication. Oil is raised from the well by means of an open gear and passed through the constant-level pans which are located under the connecting rods. From there it is splashed to all internal moving parts by the oil scoops on the ends of the rods.

Mine compressors are designed to exclude dust as far as practicable. To this end the working parts of portable machines are very frequently provided with sheet metal covers, and air filters are quite generally used to remove abrasive dust from the intake air. This assures protection of the compressor parts and tool mechanisms and also reduces the possibility of accumulation of siliceous or gummy deposits.

Cylinder lubrication requires an oil of very high lubricating ability, for minimum quantities must be used; furthermore, the oil must resist breakdown when exposed to heated air, in order to reduce the possibility of gum formations and mechanical failure of any part of the system. The degree of refinement, integrity of the producer, the tendency to form carbon deposits, the flash point and viscosity of the oil must all be considered in determining the suitability.

Carbon Deposits—The Result of Oil Breakdown

Breakdown of a compressor oil is in part responsible for deposits of carbon plus dirt on the valves or in the discharge lines of an air compressor. It is impossible to get away from this phenomenon, for mineral lubricating oils, regardless of their base or nature, will decompose to volatile products and carbon when subjected to hot air under pressure. On the other hand, the extent of this decomposition will depend upon the length of time the oil is exposed to such heat. Naturally, it will also follow that with oils of the same degree of refinement, the one which remains in the compressor cylinder or on the discharge valves the longest will form the greatest amount of carbon.

It is interesting to note that analysis of numerous so-called carbon deposits has proved them to consist more of dirt than of carbon, the whole being held together by gummy matter from decomposed oil, especially where the latter has been unsuited to the service involved.

Obviously an oil having a wide range of distillation, high end point, or too great a viscosity is objectionable, inasmuch as, instead of vaporizing cleanly, it breaks down as has been mentioned above, becoming sticky and collecting dirt brought in by the air. The longer such an oil remains in the compressor, or the greater the volume of oil involved, the more carbon will ultimately be developed with greater possibility of subsequent trouble.

Carbon in its true form may develop in air compressor cylinders in a hard mass, or it may be produced in the shape of dust and pass out with the air. In the latter case it will often collect in pockets, elbows, or on sharp edges and become mixed with dirt taken in by the air as well as with oil which has been vaporized in the cylinder and later condensed at these points.

Flash and Fire Points

The extent to which flash and fire points have been stressed by some in regard to their relation to effective compressor cylinder lubrication requires analysis of their actual importance. High flash and fire points have been decidedly over-emphasized in their relative importance as qualifications for air compressor lubricants. In fact, observation of the conditions under which explosions will tend to occur indicates that the possibility of formation

of deposits within the compressor or air lines requires far more consideration.

The cause of such deposits has been mentioned above. In any installation where they are present and rendered incandescent for any reason whatsoever, an explosion may occur irrespective of the flash or fire points of the lubricating oil. Otherwise the oil would have to be submitted to a temperature much higher than its laboratory flash point before combustion could take place. When we consider that the flash point will normally range in the neighborhood of 400 degrees Fahr., whereas the temperature of actual combustion would be very much higher, one can readily appreciate that it is unwarranted to worry as to the possibility of certain compressor oils being the more explosive, simply because their flash point may be below the temperature of the discharged air, provided that carbon or siliceous deposits are guarded against, and the valves maintained in proper condition to prevent air leaks.

Viscosity

To understand the importance of viscosity, one must realize that the body of the oil will be subject to change in its relative fluidity with change in temperature. Due to the extent to which cylinder wall temperatures will vary, the viscosity of the oil used must be given careful consideration. The degree of piston seal attainable can be judged by the indicated viscosity of the oil at the operating temperature. This will in turn affect the efficiency of compression. Too light a bodied oil; i. e., one too low in viscosity at the operating temperatures in the cylinder, might easily result in its working past the piston rings to impair the seal; too heavy an oil would, in turn, tend to develop gummy matter which would in time result in sticking of the piston rings.

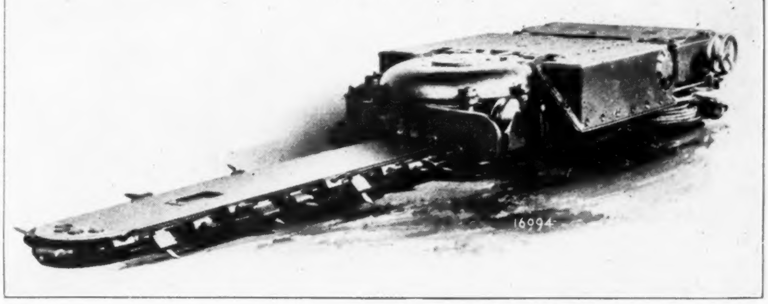
While an air compressor oil should have a viscosity high enough to sustain the weight of the moving parts, and form a proper seal between the piston rings and cylinder walls, it should never be so heavy as to atomize with difficulty or develop excessive internal friction within itself.

Moreover, if too heavy an oil is used, the resultant oil film on the cylinder walls will more easily collect any dust that may be present in the air, and on the hot surfaces, to form carbon deposits. This is especially likely to happen when more oil has been used than just sufficient to lubricate the wearing surfaces, or where an air cleaner is not used.

It is also important to remember that where compressor cylinder walls are cooled by water-jacketing the temperature of the oil layer next to the wall will normally be but little above that of the wall itself. The oil layer exposed to the heated air, however, becomes much hotter than the rest of the oil body and a portion of it may be vaporized. As oils are composite mixtures, different portions will be distilled or vaporized at different temperatures. Certain of the lighter products may pass off even at temperatures below the flash point, leaving the heavy ends dissolved in the oil next to the wall. Where an excess of high carbon content oil is used oxidation and the building up of a gummy mass which has a low vapor pressure and high distillation point may result.

AIR OPERATED DRILLS AND PICKING MACHINES

Air power can be most effectively employed in tools which function with minimum friction loss. This presents a relation of tool efficiency to lubrication, which has been thoroughly appreciated by designers of rock drills, and coal punching and picking machines. Means of lubrication have been given particularly careful study, for the average mine drill is a complicated device composed of numerous small working parts which may readily go out of commission if improperly lubricated. The air has proved to be an ideal vehicle for carrying lubricant to certain of these parts; hence the present day practice of "lubricating air" prior to its delivery to the reciprocating elements of tools. This is accomplished by locating a suitable lubricating device in the air line a short distance back from the throttle valve.



Courtesy of The Jeffrey Manufacturing Company.
Fig. 2—A Jeffrey Shortwall Coal Cutter, adaptable for thin seams. Note location of control at upper right. Lubrication has also been simplified by accessible location of all oiling points.

Those parts which require lubrication in the modern mine drill will include certain arrangements of gearing, crankshaft bearings and cylinders. The principle of the impact or

percussion type drill is akin to the steam engine, air pressure acting on the tool mechanisms in much the same manner as steam acts on the pistons of a steam engine, work being done by expansion. All this requires a number of air cylinders with their respective pistons, along with the crankshaft and connecting parts for transforming reciprocating motion into rotary motion. Gearing is also included for bringing about speed changes, just as it is in the straight rotary type.

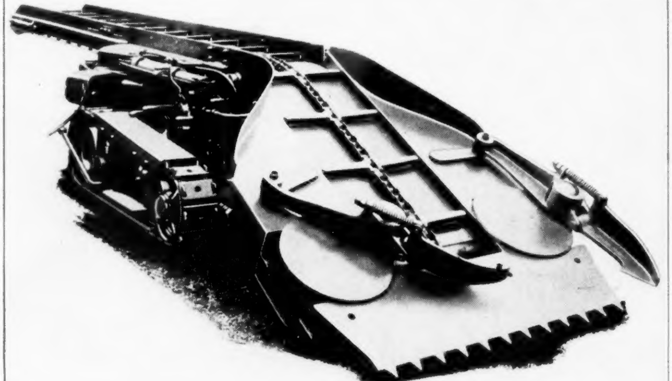
Lubrication of these parts can generally be adequately taken care of by means of two lubricants; one, of the nature of a liquid grease for the gears and crankcase bearings, etc., the other, an oil to serve the cylinders. There is an increasing tendency to equip the crankshaft of the more modern type of drill with ball bearings, the connecting rod being furnished either with plain or roller bearings. In view of this, the crankcase lubricant must be such as to lubricate these varied bearings adequately, with the least amount of internal friction and no tendency to separate. Grease for this purpose should, therefore, be selected with the utmost thought as to its stability.

There is but little possibility of dirt or dust gaining entry into either the crank or gear case of the modern drill, due to their dust proof construction. Lubricants in these elements should, therefore, function effectively for indefinite periods, with but little renewal. In operation the heaviest duty is imposed by reason of the churning action, to which such lubricants will be subjected.

Lubrication in the Presence of Water

Water in the lubricating system of a mine drill may impose a severe duty on any lubricant, however suited this may be to the actual operating requirements, due to the tendency it may have to wash off the lubricating film from wearing surfaces. It is for this reason that compounded lubricants; i. e., mineral oils containing more or less animal oil or soap in compound are recommended for the lubrication of drills and other equipment, where operating with water. Lubricants of this nature function on the same principle as do steam cylinder oils. In other words, they emulsify with water, by virtue of their fatty content, creating an adhesive emulsion which sticks tenaciously to all wearing elements, and resists the washing effects of water.

Compounded lubricants are often recommended for air drills wherein water is intentionally mixed with the air to serve the purpose of washing cuttings from the hole, in much the same manner as a soluble oil solution washes metal cuttings away from the tool in the machine shop drill, etc. Where pneumatic tools



Courtesy of Joy Manufacturing Company.

Fig. 3—Showing the Joy 8 BU type Coal Loader. Note the relative location of coal gathering arms with respect to conveyor and tractive elements.

are designed to function dry, however, they should be absolutely dry, that is, as free from moisture as possible. On such equipment straight mineral lubricants are generally regarded as most satisfactory.

The Effect of Dust and Dirt

Foreign matter, such as coal or rock dust, may gain entry through careless handling of the drill. Some dirt may also be carried through the drill by the air itself. Any such foreign matter will be detrimental and cause abnormal wear. Every attempt is normally made to obtain clean, pure air. It is not always available, however, depending upon the location of the compressor, the air intakes, whether or not air filters are installed, and the cleanliness of the air coolers and air lines.

The use of the portable mine compressor has proven advantageous in eliminating air line troubles. Regardless of the system of compression, however, the possibility of particles of rust being carried in by the air may often prevail, especially where lubrication has not been adequate in the protection of those parts of the system exposed to moisture. Then, too, particles of rubber from the air hose and gaskets may find their way into the air passages and cylinders, along with other foreign matter, to interfere materially with the free operation of the drill mechanism. To eliminate such troubles a wire strainer of suitable fineness located in the inlet pipe has been found advantageous in removing much of the above

mentioned foreign matter from the air prior to contact with the tool mechanisms.

Mine drills can be further protected against the abrasive or corrosive effects of foreign matter by study of methods of applying lubricants. Where automatic lubrication is provided by means of pipe line lubricators or atomizers which mechanically deliver the requisite amount of oil to the air lines, there will be the least possible chance of dust or dirt being carried in, provided that the oil is properly stored and handled prior to application. Where drills must be periodically oiled by hand, in the absence of automatic means of lubrication, there may be more possibility of accidental entry of dust or dirt.

Picking and Punching Machines

The lubricating problems of compressed air and electric driven picking machines are quite similar to those involved in the operation of percussion or impact type drills. Reference is, therefore, made to the discussion pertaining to such equipment. Essentially, a low pour test, medium viscosity oil will serve for normal conditions of air cylinder lubrication. For other parts of the compressed air driven puncher or snubber, as well as the electric machine, including the reduction gears, motor bearings, etc., a medium bodied grease compounded with a highly refined, low pour test straight mineral oil, will meet normal operating requirements.

COAL CUTTING OPERATIONS

Coal cutting is an operation largely confined to the bituminous or soft coal fields. In study of the lubrication requirements of the machinery employed, design must be thoroughly understood, for the duty to which both machines and lubricants are subjected is especially severe.

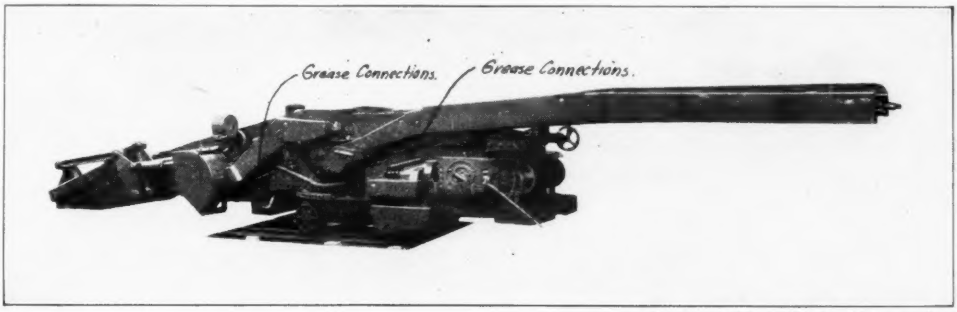
The types of lubricants to use will, of course, depend upon the housing and design of the operating parts. Some machines can be lubricated by a soft grease or an oil of from 300 to 500 seconds Saybolt viscosity at 100 degrees Fahr. In other cases where gears and bearings of these machines are oiled by the same system, this is best accomplished with a heavier oil, applied immediately after cutting while the parts are still at operating temperatures.

Lubrication of chains, by reason of their exposed nature, can best be accomplished by waste machine oil, or black oil, of sufficient fluidity to exert a certain amount of washing action over the chain links. Care should be taken to clean both the chains and machines quite often. Some operators soak the chains in oil after cutting each room.

When cutting machines are travelling, the trucks are driven through a worm and gear, which in turn drives the wheels by means of chains. All such parts, with the exception of wheel bearings, are best lubricated with a medium bodied gear lubricant of highly penetrative and adhesive characteristics. Wheel bearings should be studied with respect to construction, as discussed under mine cars.

Parts replacement is of considerable importance to the operator of coal cutters or, in fact, any type of mining machinery, for it may become quite an item on the cost records. Lubrication reduces this item because of its ability to counteract the effects of wear, just as it reduces power consumption. Wear will often be extensive on the moving elements of any coal mining machine, regardless of the attention given to lubrication, for the presence of excessive amounts of coal dust and other abrasive matter, and the possibility of dampness interfere seriously with retention and distribution of lubricants, unless parts are very tightly enclosed.

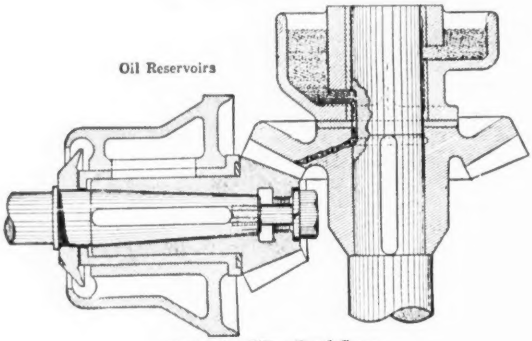
Even then certain gears and bearings will wear more than others. In such cases the best to be expected from lubrication is that it will reduce the rate at which such wear takes place, enabling gears to run in proper mesh as long as possible, and increasing the life of



Courtesy of Myers-Whaley Company, Inc.

Fig. 4—Showing diagonal rear view of a Myers-Whaley "Automat" Coal Shovel. Note location of grease connections and practice of mounting these all together at central points on the side of the machine.

bearings. As improper meshing of gear teeth develops, or bearing clearances become too great, power losses, noise and perhaps decrease in production, will occur, to presage subsequent breakdown and necessity for repair.



Courtesy of Sullivan Machine Company.

Fig. 5—Oiling plan for the bevel gears on a continuous coal cutting machine. Oil reservoirs in the top bearing of the intermediate shaft serve both the shaft bearing and gears through oil passageways as shown.

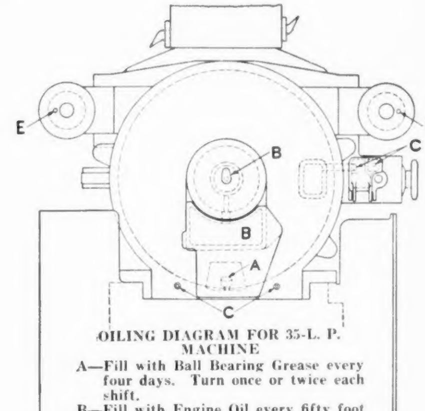
Whenever it is necessary to renew gears or bearings, it will be advisable to investigate whether or not the entire train, or all the bearings warrant renewal. Merely to install a new gear, or renew the bearing of a gear shaft will not insure correct meshing in case the companion gears or bearings are worn to any great extent. In fact, this would only lead to more rapid wear of the new element. The use of heavier grades of gear lubricants might offset high tooth clearances to a certain extent, but the increase in power consumption involved, due to possible drag would certainly not render this economical under continued operation for any length of time.

LOADING MACHINERY

Development of mechanical means for loading coal into mine cars after it has been broken out from the seam was the natural sequence to the trend toward power mining and the necessity for increased production at minimum cost. The modern coal loader is in reality a gathering, conveying and materials handling device. The gathering or scraping mechanisms dig into the loosened coal and drag it onto the conveying unit, which carries it to the mine cars.

Coal loading machinery must function in intimate contact with abrasive materials which are decidedly prone to promote wear. In consequence, the matter of lubrication must be given careful consideration, with due regard for the protection which proper choice of lubricants will insure. Gears, chains and bearings will be involved, according to the design of the machine. In addition, on certain loaders built for hydraulic operation, oil will be required in the hydraulic system. Such oil also serves to lubricate the interior parts of such a system.

The adaptability of methods of automatic lubrication has received very careful study in appreciation of the productive importance of the loading machine. Automatic lubrication may involve merely the lubrication of gearing and gear shaft bearings by splash from the oil in a reservoir which is formed by the gear case, or the use of some form of pressure lubrication, handling either grease or oil, according to requirements of the wearing elements and the manner of housing. It is advantageous in that it usually enables the lubricant to perform its intended function of reducing metallic friction and wear more effectively. Furthermore, it promotes economy of lubricants, for as a general rule, lubricating systems will be of more nearly an oil-tight nature. Such construction has a further advantage in that it more completely prevents entry of mine waters, coal dust or other abrasive foreign matter.

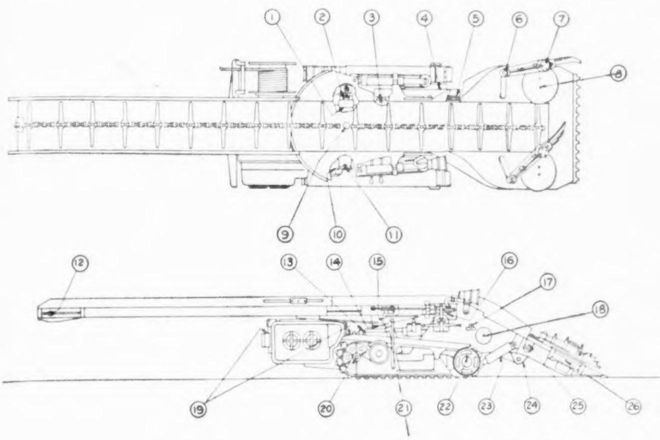


Courtesy of The Jeffrey Manufacturing Company.

Fig. 6—Oiling diagram for a Jeffrey Shortwall Coal Cutter. All parts with type of lubrication are plainly shown.

Automatic lubrication can be accomplished by use of oil or grease, according to the design of the system. Where the operating mechanism can be served from a central reservoir, it will usually be advisable to use a relatively heavy

bodied, straight mineral oil. Such a product will follow all gear and pinion teeth readily, will penetrate throughout all normal bearing clearance spaces, and will insure that chain,



Courtesy of Joy Manufacturing Company.

Fig. 7—Lubrication chart for the Joy 8 BU type coal loader with parts to be lubricated marked by number to indicate frequency of lubrication according to the schedule adopted by the manufacturer. With the exception of the main transmission shown at No. 21, all other parts are provided for grease lubrication.

roller or link mechanisms will receive an adequate amount of lubricant.

Grease of fairly low consistency can also be used in certain gear cases. Care should be taken, however, that any grease used is compounded with a high grade of low pour test mineral oil, otherwise, should low temperature conditions prevail, as in some types of near-surface mining, there will be possibility of congealment and lack of sufficient lubrication, especially if bearing clearances are comparatively low.

Where machines for coal loading purposes may involve hydraulic operation for manipulation of the gathering, shoveling or conveying elements, a high grade machine or engine oil of light to medium viscosity should be used. Such a product, if of sufficiently low pour test, should function effectively and give adequate lubrication to all plunger rods, etc. The necessity for low pour test is to insure against the oil becoming so sluggish at low temperatures as to require excessive power consumption in the operation of the plungers and connecting parts.

The exposed parts of the average coal loader, such as the chains, tractive elements, bearings, etc., which may require periodic hand lubrication can be served by machine oil of about 200 seconds Saybolt viscosity, or a medium consistency cup grease, according to the means provided for application. Exposed gears, in turn, require a straight mineral, semi-fluid lubricant of from 1,000 to 2,000 seconds Saybolt viscosity at 210 degrees Fahr. Such a product will insure adequate protection of gear teeth, with minimum loss through dripping or the action of centrifugal force.

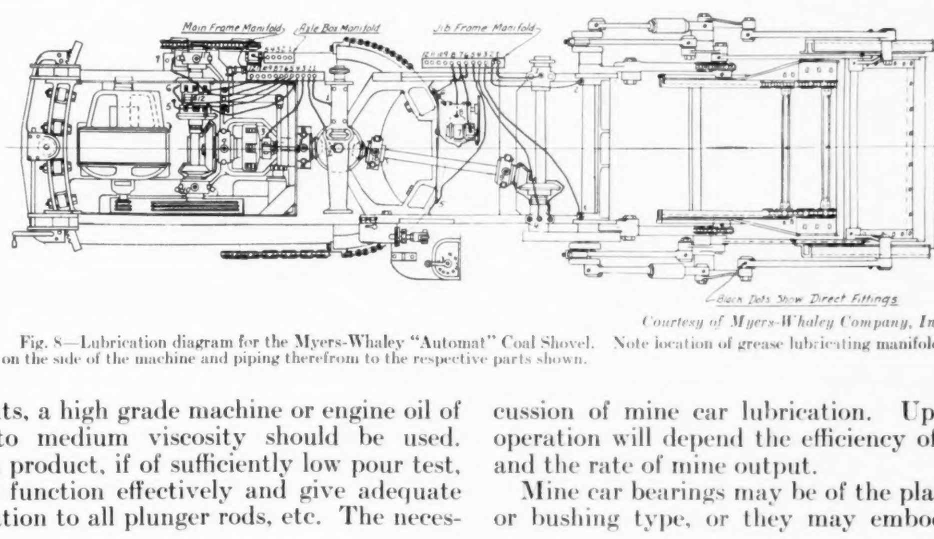
COAL HANDLING MACHINERY

Methods of handling coal from the mine to the breaker or tipple will depend upon the locality of the mine and its adaptability to modern equipment. The mine car is almost universally employed for direct handling from the mine to the breaker or tipple. In some localities, however, where the mines may be located at a considerable distance from the breaker, and where overland haulage would require crossing valleys or even rivers, the aerial tramway has been developed to a high degree of efficiency.

Mine Car Lubrication

From a constructional viewpoint, the wheel bearings are of chief importance in any discussion of mine car lubrication. Upon their operation will depend the efficiency of the car and the rate of mine output.

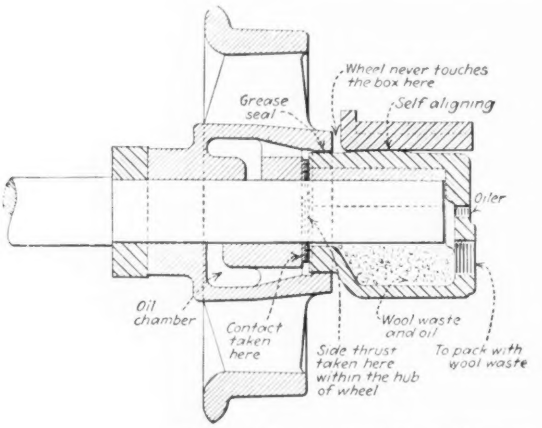
Mine car bearings may be of the plain sleeve or bushing type, or they may embody some



Courtesy of Myers-Whaley Company, Inc.

Fig. 8—Lubrication diagram for the Myers-Whaley "Automat" Coal Shovel. Note location of grease lubricating manifolds on the side of the machine and piping therefrom to the respective parts shown.

form of ball or roller bearing. Use of the latter has been extensive in the modernization of many coal mines, for they afford decidedly positive lubrication, with comparatively little possibility of abnormal power consumption.



Courtesy of American Car & Foundry Company

Fig. 9—Showing oil lubricated type of mine car wheel, with oil chamber located in the hub. A grease seal is provided to prevent leakage of oil. All parts are plainly indicated

The labor of lubrication is also considerably reduced.

Haulage Equipment

There has also been marked progress in the manner of handling mine cars to and from the mines. In the modern coal mine the mule is being largely replaced by electric or air driven locomotives. Electric locomotives are of low, enclosed construction and may be driven by power from a trolley wire or from storage batteries. The trolley system is more apt to be used in main gangways and the battery type in shorter leads. Air driven locomotives derive their power from storage tanks, where the air pressure may be as high as 1500 pounds per square inch. These are charged by air compressors which usually are located in the power house.

Wheel Bearings

Mine car bearings will frequently require a greater volume of lubricant than all the other mechanisms in the mine. This will be particularly true of the plain bearing type, where leakage may be prevalent. For this reason, lubrication of these latter is a matter of daily routine, black oils or cheap greases being applied by hand.

Such lubrication, however, is usually independable, and the labor cost is abnormally high. Furthermore, there is no assurance of positive lubrication, or protection of the bearings against entry of moisture, coal dust or other material which would lead to wear or corrosion.

These conditions have been productive of considerable study in the interest of reducing cost of replacement, and increase in labor economies, by improvement in mine car wheel bearing design.

Positive and relatively automatic lubrication must be attained if mine cars are to stand up under the higher speeds resulting from the use of the mine locomotive. Reduction in load required to move the cars means the possibility of handling more cars per train. This is decidedly advantageous in the interest of increased production.

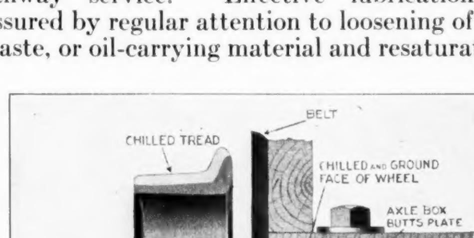
Lubricating Requirements

The lubricating requirements of the various types of car wheel bearings can be best understood by study of constructional features as they pertain to:

The plain sleeve type bearing
The hollow axle type
The cavity, or self oiling design and
Ball bearings, or roller bearings of the solid or flexible type.

Sleeve Type Bearings

Many such bearings are so constructed as to enable the use of oil-saturated wool yarn or waste packing, design of the housing being very similar to that so extensively used in railway service. Effective lubrication is assured by regular attention to loosening of the waste, or oil-carrying material and resaturating



Courtesy of Southern Car & Manufacturing Company.

Fig. 10—Showing a hollow axle type of mine car wheel lubricating system. All parts are clearly indicated. Note in particular that the lubrication ports or perforations are directly over the gauge line and that the anular grooves in the wheel always run in register with the ports.

with a suitable grade of straight mineral machine or car oil, or a light grade of liquid grease. Matting or glazing of the oil-carrying materials should never be allowed to occur, for this will reduce the capillarity of the pack-

ing, and prevent the requisite amount of lubricant from being transmitted to the contact surface.

An experienced operator should be employed for packing of journal or car wheel bearing boxes, because handling of packing as well as determination of the extent to which proper lubrication is being obtained can only be thoroughly learned by long practice. The waste or wool yarn should be of good quality, long strand material. It should be saturated in accordance with standard railway practice, for a period of 48 hours at 70 degrees Fahr., then drained until the oil content is approximately 2 pints per pound of waste; usually this will require about 24 hours. It should then be packed in a homogeneous mass, not too tightly, and yet in a sufficiently compact manner to insure continued contact with the axle.

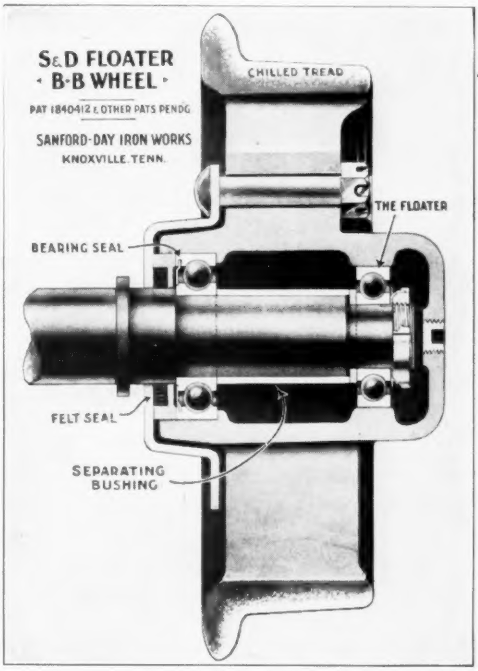
Hollow Axle Design

This type of construction involves hollow axles of tubular steel, the hole extending completely through the axle, which acts as a reservoir for lubricant. At the outer end of the axle, near each extremity is a steel cup and a spring loaded valve similar to an ordinary check valve with the exception that the guide is several inches long. A spiral spring encircles the valve stem and compels the valve to maintain a bearing on the seat, thus preventing leakage of the lubricant from the axle. At the point on the axle corresponding to the bearing surface of the wheels, the axle tube is perforated sufficiently to permit passage of the lubricant from within the axle outward to the contact surface of the axle with the inner bushing of the wheel hub. In this way the lubricant is constantly working its way outward to maintain a protective film between the wearing parts, and when the proper type of lubricant is used there is assurance of minimum cost of maintenance and parts renewal.

Experience has proved that grease of comparatively low consistency is very well adapted to this type of design, although the design will permit of oil lubrication where desired. Normally where axle sealing valves function effectively a charge of lubricant within the axle is capable of functioning from 3 to 4 months without renewal.

Cavity or Self-Oiling Wheels

The cavity type of mine car wheel is lubricated from an oil or grease reservoir around the hub. During rotation the lubricant is fed to the axle or journal through port holes staggered in the hub. Such delivery of lubricant, however, only occurs when the car is idle or running slowly. At higher speeds centrifugal force tends to carry the lubricant to the outer surface of the reservoir. For this reason, due to possibility of leakage, care should be observed in regard to the amount of lubricant used. In general, the lubricant level should be



Courtesy of Sanford-Day Iron Works, Inc.

Fig. 11—Showing the S. & D. floater type ball bearing mine car wheel equipped with Fafnir ball bearings. All parts are plainly indicated.

maintained on a line with the lower part of the axle when the car is at rest.

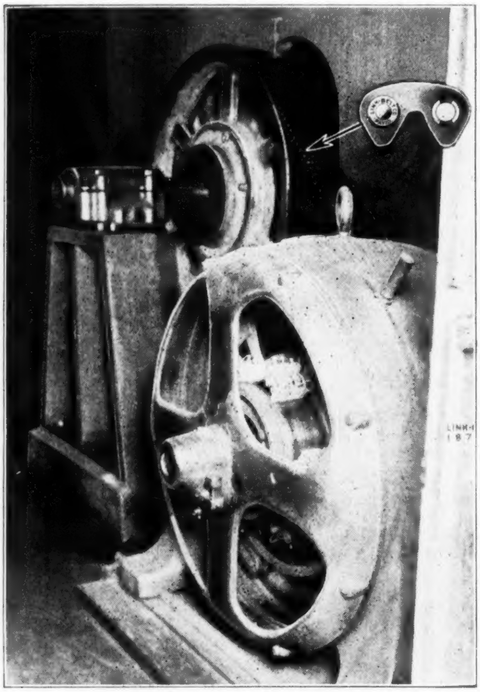
A highly refined straight mineral engine or car oil of medium to heavy viscosity will in general be best suited to the operating conditions and will insure most complete protection of the bearings. Where service in cold weather is essential, viscosity should be reduced and the oil should have a sufficiently low pour test to insure proper flow through the distributing ports.

It is also perfectly practicable to use a mine car grease where there is possibility of oil leakage. Here again a low pour test on the oil content is advantageous. Wheels designed for grease lubrication are similar to those which are to be served with oil, with the exception that frequently larger ports are used to facilitate passage of grease to the bearings.

Ball and Roller Bearings

Extension of the ball and roller bearing to mine car service has been a decided step forward in the interest of positive lubrication and labor reduction. A typical installation showing constructional details and method of

sealing as applied to ball bearings can be noted in Fig. 11. In this particular design the hub race of the outer bearing serves as a floating element, the inner bearing being locked to both axle and wheel. This construction is



Courtesy of Link-Belt Company.

Fig. 12—Showing a Link-Belt Silent Chain Drive operating a mine fan. Note the relative location of the belt with respect to driving motor and fan bearings.

claimed to reduce lateral play and thereby decrease the possible entry of dirt or leakage of lubricant.

The protective nature of the seals permits the use of high quality grease for lubrication. Normally such a grease should be compounded with a fairly high viscosity straight mineral oil in order to obtain load carrying ability. By use of lubricants of maximum lubricating value, the frequency of re-lubrication can be reduced and the bearing elements more effectively protected.

Roller bearings are also decidedly positive, automatic and economical from a lubricating point of view. By reason of their careful construction all lubricants used should likewise be of the highest degree of refinement, and selected with the utmost caution. The function of these latter is dual in that they must not only protect the rolling elements against corrosion, but also lubricate the contact surfaces of the bearing rolls and retainers.

Experience has indicated that soft or semi-fluid greases are best suited for roller bearings in mine car service. Where the latter are of solid, cylindrical or tapered construction, a somewhat more inert grease will be advisable than on hollow flexible bearings. It will be found that such a product will furnish a better cushion between the axle and rollers than a more liquid grease. Furthermore, it will also form a better seal against possible entry of dust, dirt or water, provided the bearing itself is equipped with a reasonably tight seal. Lubrication of flexible roller bearings, however, can be best accomplished with a semi-fluid or so-called liquid grease. The usual construction of such bearings provides for the hollow spaces within the rollers serving as grease reservoirs. In consequence, the lubricant must be sufficiently fluid to pass through and penetrate to all the surfaces of contact. It should never remain inert within the rollers, or tend to gum, otherwise protection of the bearings will be seriously impaired.

Where roller bearings are of a relatively oil and dust-tight construction they should not require re-lubrication more frequently than once every few months. Wherever possible the lubricant should be applied by a pressure gun of capacity commensurate with the proper amount of lubricant required per bearing. In this way, just the right amount, as recommended by the manufacturers, can be injected, with the least possibility of subsequent leakage or development of abnormal internal friction. Certain authorities also suggest removal of fixed pressure gun fittings, to prevent careless operators from using a pressure gun too freely, the lubricating orifice being sealed with a pipe plug. Others feel that actual hand packing of such bearings will best control the amount of grease used.

Mine Locomotives

Inasmuch as mine locomotives operate under much the same conditions as do mine cars, their lubrication requirements are similar to other underground mining machinery. Axle bearings are lubricated according to the type of bearing; the same recommendations apply as for mine cars.

Gears, in turn, require the use of a straight mineral, residual lubricant of about 1,000 seconds Saybolt viscosity at 210 degrees Fahr. Such a product will adhere tenaciously to the gear teeth and overcome vibration and wear. This same lubricant should also be used on chain drives. On the other hand, where gears and chains are enclosed in oil-tight housings, a somewhat lighter lubricant can be used to advantage, with the possibility of reduction in drag and power consumption. The pour test of such lubricants must be considered, for the probability of low temperature service above ground will always prevail. Obviously

a gear lubricant should be capable of following the gear teeth readily, otherwise its very purpose may be defeated if abnormal wear results. The degree to which satisfactory performance can be predicted is indicated by the pour test and relative change in viscosity with change in temperature.

WIRE ROPE

Wire rope has become a most important factor in the operation of mine haulage and hoisting equipment, with the extension of deeper shafts and working of considerably lower levels than was customary in earlier coal field operations. When short lifts were more prevalent, a broken rope might be serious, but not necessarily fatal. Today, however, with hoisting operations requiring several hundred feet of rope, and cable tramways stretching for a matter of miles, it is obvious that every precaution must be taken to insure against undue wear or corrosion which might lead to breakage at the cost of lives of men and serious disruption of the entire production program. Such protection is best assured by effective lubrication.

Lubrication of wire rope is distinctive as compared with lubrication of any other type of mine machinery or mechanism, in that it must function both internally and externally. In other words, the inner strands of the rope must not only be prevented from coming into actual frictional contact with one another, especially when the rope is flexed in passing over sheaves or hoisting drums, but also there must be means to prevent entry of water, acids or dirt which would cause corrosion and abrasion. Straight mineral lubricants of comparatively heavy body and a high degree of adhesiveness have been found to serve this purpose most effectively.

In the manufacture of the rope they are used to saturate the hempen core, thereby enabling the latter to serve as a storage reservoir from which a small amount of lubricant can be squeezed out as flexing or bending occurs. If periodically the surface of the rope is then treated with a similar lubricant, an external seal will be maintained, the surface strands being at the same time prevented from wearing abnormally as they pass over the hoisting machines. The ropes of the aerial tramways of course do not bend as severely, but constant exposure to the weather calls for quite as careful protection in the interest of preventing corrosion and wear from trolley wheels.

The Occurrence of Friction

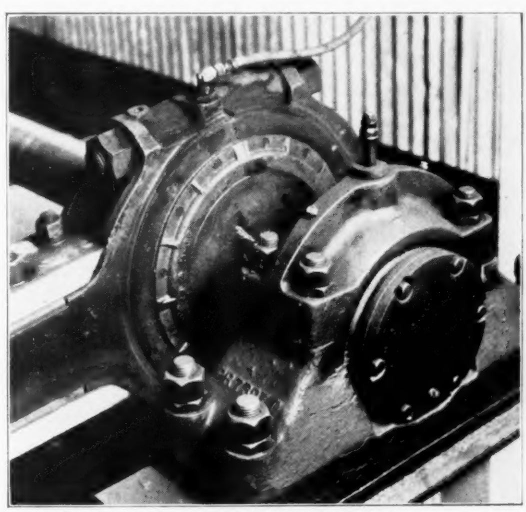
One should never assume that because wire ropes come from the manufacturers in a lubricated state that further lubrication is unnecessary. Under operation there is constant friction and wear between the strands, and a tendency to squeeze out any contained lubricant, especially when the ropes pass over sheaves or around drums. The renewal of this product is, therefore, an absolute necessity.

The matter of friction between the strands of a wire rope is essentially the same as friction between a bearing and shaft. It can only be overcome by effective lubrication, brought about by the proper application of a suitably prepared wire rope compound, which will be capable of not only penetrating to the innermost strands and core of the rope, but also sufficiently adhesive and viscous to resist being prematurely squeezed out, or washed off when in contact with water.

Lubricant Characteristics

In addition to the properties mentioned above, a wire rope lubricant must show no tendency to cake, gum or ball up, especially if contaminated with an excess of dust, dirt or metallic particles. Furthermore, it must be resistant to the thinning-down effects of higher temperature. This, of course, directly involves the viscosity or relative fluidity of the product. In fact, viscosity of such products is the essential characteristic involved in purchasing. It should not, however, be assumed as being the chief guide as to the actual suitability of the product.

In this regard the ability of the latter to



Courtesy of The Philadelphia & Reading Coal & Iron Company.

Fig. 13—A shaker cam designed for automatic lubrication. This cam is mounted on a Hyatt type roller bearing equipped for pressure grease lubrication. Connection for lubrication is shown at the ton of cam element.

function, penetrate and stick under actual operating conditions, is of outstanding importance. In consequence such products should not be purchased haphazardly, nor on a price

basis alone. The potential difficulties that might result in cold weather are too serious.

According to the operating temperatures that may be involved, and the possibility of the presence of an excess of water, the viscosity of a wire rope lubricant should range from 500 to 2000 seconds Saybolt at 210 degrees Fahr. In warm climates, where there might be possibility of such a product thinning down to the extent of dripping off to perhaps result in lack of lubrication, it will be advisable to use a lubricant in the higher viscosity range, in accordance with the temperature prevalent.

On the other hand, under relatively cold conditions it would be advisable to resort to a thinner product, again in accordance with the range of operating temperatures involved.

Wire rope lubricants to meet the aforesaid requirements should, in general, be straight mineral petroleum products, devoid of fillers or thickening mediums. In other words, whatever the viscosity, it should be an inherent property of the lubricant, not an artificial characteristic which cannot be depended upon.

Application of Wire Rope Lubricants

High viscosity wire rope lubricants, by virtue of their inertness can best be applied in heated condition. Merely to daub or paint a rope with such a product at normal temperatures would be relatively impossible. Even though the surface might be more or less coated, the possibility of penetration occurring to any extent would be remote. We must realize that this latter is the secret of effective wire rope lubrication. The amount of wear occurring between the exterior of such a rope and the sheaves is not as marked as that which occurs between adjacent strands when the rope is flexed or bent, as in passing over sheaves or hoisting drums.

A very satisfactory method of treating wire ropes is to use a form of split box through which the rope can be run. Such a box can be readily built in the average machine shop, with suitable provision for rendering it sufficiently tight to prevent the lubricant from leaking out, even when reduced in viscosity by heating. The slow passage of the rope through such a bath of heated compound will insure that not only will the surface be coated, but also that the requisite penetration takes place to the inner strands. Further working of the rope over the sheaves before the lubricant has time to cool entirely will tend to aid in bringing about the maximum of penetration.

BREAKING, CLEANING AND SCREENING MACHINERY

Modernization of breaking and cleaning machinery has resulted in a marked trend towards adoption of pressure lubrication and certain types of anti-friction bearings. Grease lubrication has been found to be very satisfactory on such machinery. It is advantageous in that grease under sufficient pressure will effectively protect the bearings against entry of coal or abrasive dust. Where certain bearings may be designed for oil lubrication, however, a straight mineral machine oil of approximately 500 seconds Saybolt viscosity at 100 degrees Fahr., will in general carry the pressures satisfactorily.

Under abnormal water conditions pressure grease lubrication is decidedly effective. The grease should be highly resistant to solubility, however, due to the possibility of its having to withstand the direct washing action of water during the screening process. As a rule, a grease of medium body or consistency will be best suited to these conditions and capable of ready application by means of some form of compression cup or pressure lubricator.

Temperature must also be considered. Cam operations require study in this regard. Where Cams may tend to run hot, a problem of underlubrication and abnormal wear of cams and straps may frequently develop. The proper lubricant to counter-act such conditions is a high melting point grease of relatively heavy consistency. The lubricating film developed by such a grease is decidedly tenacious, resistant to the thinning out effects of higher temperatures, and capable of withstanding high pressures.

Gear lubrication, in turn, may develop problems whatever the method of coal treatment. Many of such gears with the accessory driving chains will operate exposed on certain machines. For these elements a lubricant must be used which will not only form a protective film to counter-act the abrasive effect of dust, dirt, etc., but will function irrespective of temperature, moisture or weather conditions. This is a broad requirement; one, in fact, that very few compounded lubricants or greases will meet with any degree of success. Experience has proved that a straight mineral residual product of fairly inert characteristics will give the most satisfactory results. Under exposed conditions a viscosity of from 1000 to 2000 seconds Saybolt at 210 degrees Fahr., will be required.

Where gears and chains are housed and capable of bath lubrication, however, the viscosity of the lubricant can be reduced to permit the use of a more fluid product, similar to a transmission lubricant. Heavier lubricants are advantageous in that their highly adhesive characteristics enable them to resist the effects of centrifugal force under higher speed conditions, provided they are sparsely applied, yet with sufficient frequency to insure maintenance of a suitable film. They are also more resistant to the washing-off effects of water.

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